VERIFICATION OF TRANSLATION

I, Hideaki Morioka, of ISONO INTERNATIONAL PATENT OFFICE, Sabo-kaikan Annex, 7-4, Hirakawa-cho 2-chome, Chiyoda-ku, Tokyo, Japan, am the translator of the documents attached and state that the attached document is a true and complete translation to the best of my knowledge of Japanese Patent Application No. 2000-223194.

Dated this day of July 8, 2004

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【Name of Document】 Patent application

【Reference Number】 H100138801

【Filing Date】 July 25,Heisei 12

【Addressed to】 Commissioner of Patent Office

【International Classification】 H01M 8/04

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【Display of Commission】

【Ledger Number】 015392

【Paid Commission】 21,000 Yen

【Summary of addressed document】

【Document Name】 Specification 1

【Document Name】	Figure 1
【Document Name】	Abstract 1
【Number of General Power of Attorney】	9713945
【Request of Proof】	Yes

[Name of Document] Specification

[Title of the Invention] FUEL CELL SYSTEM AND PROCESS FOR CONTROLLING THE SAME

[Claims]

[Claim 1]

A fuel cell system comprising:

a fuel cell;

a supercharger for compressing air and sending the compressed air to a cathode inlet side of the fuel cell;

a backpressure control valve capable of controlling backpressure of air exhausted from a cathode outlet side of the fuel cell;

a flow amount sensor for sensing a flow amount of air to the cathode inlet side;

an airflow amount control means for controlling the flow amount of the air to the cathode inlet side to a target airflow amount in accordance with a target electric generation amount of the fuel cell by controlling a rotation speed of the supercharger; and

an air pressure control means for controlling the air pressure to the cathode inlet side to target air pressure in accordance with the target airflow amount by controlling an opening of the backpressure control valve,

the fuel cell system characterized by comprising

a transitional air pressure control means for sequentially controlling air pressure to the target air

pressure by controlling the opening of the backpressure control valve, in accordance with change in the airflow sequentially sensed by the airflow sensor, during a transition period over which the airflow amount is sequentially changed to the target airflow amount accompanied by change in the target electric generation amount.

[Claim 2]

A fuel cell system according to claim 1 characterized in that

the transitional air pressure control means sequentially controls the opening of the backpressure control valve in accordance with airflow sequentially sensed by the flow amount sensor and the target air pressure.

[Claim 3]

A fuel cell system according to claim 1 or 2 characterized in that

the transitional air pressure control means keeps acting until the airflow amount reaches the target airflow amount.

[Claim 4]

A process for controlling a fuel cell system for controlling an electric generation amount from a fuel cell by controlling an flow amount and pressure of air compressed and sent to a cathode inlet side of the fuel cell to a target airflow

amount and target air pressure, respectively, wherein

the air pressure is sequentially controlled to the target air pressure, in accordance with sequential change in the airflow, during a transition period over which the airflow amount is sequentially changed to the target airflow amount accompanied by change in the electric generation amount of the fuel cell.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to a fuel cell system which generates electricity through the chemical reaction between hydrogen and oxygen, and process for controlling the fuel cell in the fuel cell system. More particularly, the invention relates to a fuel cell system having improved performance during the transition period, at which the power generation amount is changed, and a process for controlling the fuel cell system.

[0002]

[Related Art]

In recent years, electric powered vehicles each carrying various driving motors instead of conventional engine has been developed. One example of such types of electric powered vehicles includes a fuel cell carried vehicle having a Proton Exchange Membrane Fuel Cell (PEM FC) (hereinafter PEM type fuel

cell or simply referred to as fuel cell) as a power source for a driving motor, and such PEM type fuel cell carried vehicles have been sharply developed.

[0003]

PEM FC comprises a stack structure having a lot of single cells, which are power generation units, laminated on each other. Each cell has a configuration composed of an anode side separator having a hydrogen passage, a cathode side separator having an oxygen passage, and a membrane-electrode assembly (hereinafter abbreviated as "MEA") intervened between these separators. MEA is composed of a proton exchange membrane abbreviated as PEM, each surface of PEM with a catalyst layer and a gas diffusion layer laminated one after another (one surface having an anode side catalyst layer and a gas diffusion layer and the other having a cathode side catalyst layer and a gas diffusion layer).

[0004]

In such PEM FC, when hydrogen gas flows through the hydrogen passage from the inlet side to the outlet side of the anode and when air (as an oxidant gas) flows through the oxygen passage from the inlet side to the outlet side of the cathode, the protons permeate through PEM of MEA in a wet state from the anode side of each cell, migrating to the cathode side. This causes each cell to generate electromotive force of approximately 1 V. In PEM FC having such a power generation mechanism, air and hydrogen are continuously supplied to

continue the power generation. Consequently, an air intake system, which compresses and blows air, for example, by a compressor is provided at the inlet side of cathode, and an air exhaust system, for example, having a backpressure control valve, is provided on the outlet side of cathode. In addition, a hydrogen gas supply system, which supplies hydrogen by an ejector, is provided on the inlet side of anode.

[0005]

As described above, in the fuel cell system having the air supply system, the air exhaust system, and the hydrogen supply system provided on the fuel cell, the revolution speed of the compressor is controlled to be increased or decreased by increasing or decreasing an amount of the air flowing to the cathode inlet, whereby a power generation amount (output current or output power) is controlled (increased or decreased). At this time, if the pressure difference between the poles, i.e., the difference between the hydrogen gas pressure and the air gas pressure acting on the both sides of MEA in the fuel cell, becomes unduly large, there is a fear of breaking PEM making up MEA. Consequently, the hydrogen gas pressure at the anode inlet side and the air pressure at the cathode inlet side are separately controlled so that the pressure difference between the poles falls within a tolerance range. Specifically, in the conventional fuel cell system, the revolution speed of the compressor is controlled to be a target value where the air-flow amount to the cathode inlet side is controlled to be a target

air flow amount, and the opening of the backpressure control valve of the air exhaust system is controlled so that the air pressure becomes a target pressure.

[0006]

[Problems to be Solved]

Meanwhile, it takes a very short period that the opening of the backpressure control valve reaches a target value in comparison with the period that the air pressure reaches a target air pressure. However, in the conventional fuel cell system, the opening of the backpressure control valve is sharply controlled so as to be a target value corresponding to the target airflow amount. For example, as shown in Fig. 5, when the airflow amount Q is increased to a given target airflow amount QT, the opening γ of the backpressure control valve is sharply controlled to be a target value corresponding to the target airflow amount QT as shown in the broken line. For this reason, at the transition period until the airflow amount Q reaches the target airflow amount QT, the backpressure control valve is excessively wide-opened to the target opening corresponding to the target airflow amount QT in advance and, thus, the pressure P of the air to be compressively transferred toward the cathode inlet by a supercharger is escaped toward downstream of the backpressure control valve. As a result, the air pressure P at the cathode inlet side is once decreased and then reaches a target air pressure PT, conducting that the pressure increase is delayed. The behavior at the time when

the airflow amount Q is decreased to a given target airflow amount QT is that the air pressure P is once increased, and then reaches the target air pressure PT during the transition period, delaying the decreasing of the pressure.

[0007]

In the conventional fuel cell system as described above, during the transition period when the airflow amount at the cathode inlet side is increased or decreased to a target airflow amount corresponding to the decreasing or increasing of the power generation amount, the air pressure at the cathode inlet side is once decreased or increased. Accordingly, there arises a problem that pressure difference between the poles in the fuel cell system (pressure difference between the anode side and the cathode side applied to PEM of MEA) is increased. Also, the conventional fuel cell system is disadvantageous in that there is a time lag until the air pressure at the cathode inlet reaches a target air pressure, leading to poor responsibility.

[0008]

It is, therefore, an object of the present invention is to provide a fuel cell system and a process for controlling the same, which can prevent the increase in the pressure difference between the poles in the fuel cell during the transition period when the airflow amount toward the cathode inlet reaches a target airflow amount, and which can solve a time lag until the air pressure at the cathode inlet side reaches a target air pressure.

[0009]

[Means for solving the Problems]

As a means for solving the above problems, a fuel cell system according to the present invention is constituted as follows:

(a) a fuel cell;

(b) a supercharger for compressing air and sending the compressed air to a cathode inlet side of the fuel cell;

(c) a backpressure control valve capable of controlling backpressure of air exhausted from a cathode outlet side of the fuel cell;

(d) a flow amount sensor for sensing a flow amount of air to the cathode inlet side;

(e) an airflow amount control means for controlling the flow amount of the air to the cathode inlet side to a target airflow amount in accordance with a target electric generation amount of the fuel cell by controlling a rotation speed of the supercharger; and

(f) an air pressure control means for controlling the air pressure to the cathode inlet side to target air pressure in accordance with the target airflow amount by controlling an opening of the backpressure control valve.

Further, the fuel cell system is characterized by including a transitional air pressure control means for sequentially controlling air pressure to the target air pressure by controlling the opening of the backpressure control

valve, in accordance with change in the airflow sequentially sensed by the airflow sensor, during a transition period over which the airflow amount is sequentially changed to the target airflow amount accompanied by change in the target electric generation amount.

[0010]

In the fuel cell system according to the present invention, the transitional air pressure control means sequentially controls air pressure at the cathode inlet side to the target air pressure, in accordance with the change in the airflow amount to the cathode inlet side sequentially sensed by the flow amount sensor, during a transition period over which an airflow amount flowing to the cathode inlet side of the fuel cell is gradually changed toward the target airflow amount accompanied by the change in the target electric generation amount. This enables prevention of the increase in the pressure difference between the poles within the fuel cell, and solution of time delay by which air pressure at a cathode inlet side reaches the target air pressure.

[0011]

In the fuel cell system according to the present invention, the transitional air pressure control means keeps acting until the airflow amount flowing to the cathode inlet reaches the target airflow amount. In this case, the transitional air pressure control means sequentially controls the opening of the backpressure control valve by means of, for example, map

searching technique in accordance with the airflow amount sequentially sensed by the flow amount sensor and the target air pressure depending on the target airflow amount.

[0012]

As a means for solving the above problems, a process for controlling a fuel cell system according to the present invention controls an electric generation amount from a fuel cell by controlling an flow amount and pressure of air compressed and sent to a cathode inlet side of the fuel cell to a target airflow amount and target air pressure, respectively. Further, the process is characterized in that the air pressure is sequentially controlled to the target air pressure, in accordance with sequential change in the airflow, during a transition period over which the airflow amount is sequentially changed to the target airflow amount accompanied by change in the electric generation amount of the fuel cell.

[0013]

[Description of the Preferred Embodiments]

Embodiments of a fuel cell system and a process for controlling the fuel cell system according to the present invention will now be described by referring to the attached drawings. In the drawing, Fig. 1 is a configuration diagram of a vehicle drive system including a fuel cell system carried on a vehicle according to one embodiment of the present invention, Fig. 2 is a functional block diagram of a control system of a fuel cell system according to one embodiment of the

present invention, and Fig. 3 is a graph showing the relation between a target airflow amount and a target air pressure in the fuel cell system according to one embodiment of the present invention.

[0014]

First, the configuration of a vehicle drive system of a vehicle having a fuel cell system according to one embodiment of the present invention carried thereon will now be described by referring to Fig. 1. The vehicle is a so-called an electric vehicle which carries a fuel cell (FC) 3 as an electric power source for a power driving motor (traction motor) (EVM) 2, which rotatably drives a traveling wheel 1. The fuel cell (FC) 3 has a circuit configuration that the fuel cell (FC) 3 feeds power to a power driving unit (PDU) 5 and a battery 6 via a high-pressure distributor (DC/DC) 4. The power driving unit 5 has a circuit configuration so that the power driving unit 5 at least drives the power driving motor 2 described above, and a driving motor 7F for a supercharger (S/C) 7B, which serves as a compressor and which will be described fully later on.

[0015]

The fuel cell (FC) 3 is a PEM type fuel cell having a plurality of cells, each of which is a power generation unit, laminated thereon. The fuel cell (FC) 3 has an air intake system 7 which supplies air (oxygen) to a cathode inlet side, and an air exhaust system 8 which discharges the air from the cathode outlet side. Also provided on the fuel cell (FC) 3 is a hydrogen

intake system 9 which supplies hydrogen gas to an anode inlet side.

[0016]

On the air intake system 7 of the fuel cell (FC) 3, from the upstream side toward the downstream side, an air cleaner (A/C) 7A, the supercharger (S/C) 7B, and an intercooler (heat exchanger) (H/C) 7C are placed. The air intake system 7 has a flow mater 7D which detects an amount of air flowing toward the cathode inlet side and which is provided on the upstream of the supercharger (S/C) 7B, and a pressure sensor 7E which detects an air pressure around the cathode inlet of the fuel cell (FC) 3.

[0017]

Any air type of cleaner can be used as the air cleaner (A/C) 7, as long as it has a function of filtering the flowing air. It is also possible to provide an air-intake silencer such as a resonator at the upstream side of the air cleaner (A/C) 7A.

[0018]

The supercharger (S/C) 7B can be driven at a rotation speed ranging from 0 to 12,000 rpm, and can linearly change an airflow amount Q depending upon the rotation speed. The supercharger (S/C) 7B is driven in a rotatable manner through driving current supplied at a given duty ratio supplied from the drive unit (PDU) 5, whose rotation number is controlled in a variable manner at a changing ratio of 12,000 rpm.

[0019]

The intercooler (H/E) 7C serves as a heat exchanger which can cool the power driving motor (EVM) 2, the fuel cell (FC) 3, the high-pressure distributor (DC/DC) 4, the power driving unit (PDU) 5, and the driving motor 7F for cooling in a thermally exchangeable manner through a coolant.

[0020]

Examples of the flow sensor 7D include various types of airflow sensors (airometers), such as vane type, Karman vortex type, and hot-wire type airflow sensors. As the pressure sensor 7E, an appropriate type pressure sensor, such as a semiconductor type pressure sensor, can be used.

[0021]

The air exhaust system 8 of the fuel cell (FC) 3 has a backpressure control valve 8A for controlling air pressure P at the cathode inlet side of the fuel cell (FC) 3. The backpressure control valve 8A has a CV value (capacity of valve) of about 8.5 and the valve-opening speed of approximately 8,000 degree/sec. In the backpressure control valve 8A, the opening is controlled at a interval of 10 ms.

[0022]

On the other hand, from the upstream toward the downstream, the hydrogen intake system 9 of the fuel cell (FC) 3 has a hydrogen tank 9A, a pressure control valve 9B, and ejector 9C. Unused hydrogen gas exhausted from the anode outlet is returned to the ejector 9C.

[0023]

The fuel cell system according to one embodiment of the present invention has a control unit 11 which at least receives detected signals from the flow sensor 7D, the pressure sensor 7E, an accelerator sensor 10, which will be described fully later on, and which outputs the control signals to the power driving unit (PDU) 5, the backpressure control valve 8A, and the pressure control valve 9B, respectively. The control unit 11 is composed of, as hardware, an input/output interface I/O between the control unit 11 and the flow sensor 7D, the pressure sensor 7E, the accelerator sensor 10, the backpressure control valve 8A, the pressure control valve 9B, etc., and an analog/digital (A/D) converter, which converts analog signals input from the flow sensor 7D, the pressure sensor 7E and the accelerator sensor 10 to digital signals, Read Only Memory (ROM), which memorizes various data and programs, as well as Random Access Memory (RAM), which temporarily memorizes various data, central processing unit (CPU), which executes various calculation, and the like.

[0024]

As the software configuration for controlling the fuel cell system, the control unit 11 is composed of airflow control means (program), which controls the flow amount Q of the air flowing toward the cathode inlet side of the fuel cell (FC) 3 to be a target airflow amount corresponding to a target power generation amount of the fuel cell (FC) 3 by controlling the rotation speed of the supercharger (S/C) 7B, and air pressure

control means (program), which controls the air pressure P at the cathode inlet to be a target air pressure corresponding to the target airflow amount through controlling the opening of the backpressure control valve 8A. Also, contained in the control unit 11 is hydrogen gas pressure control means (program), which controls the hydrogen gas pressure at the anode inlet side to be a target hydrogen pressure corresponding to the target air pressure through controlling the opening of the pressure control valve 9B. Particularly, the control unit 11 according to this embodiment has air pressure control means during the transition period. Specifically, during the transition period that the airflow amount Q is gradually changed toward the target airflow amount according to the change in a target power generation amount, the opening of the backpressure control valve 8A is controlled one after another corresponding to the change in the airflow amount Q, which is detected by the flow sensor 7D one after another whereby air pressure control means, which controls the air pressure P during the transition period is controlled one after another is configured.

[0025]

In order to attain the functions of the airflow amount control means, the air pressure control means, the hydrogen gas pressure control means, and the air pressure control means during the transition period, the control unit 11 has respective functional blocks as shown in Fig. 2. Specifically,

as a block for attaining the function of the airflow amount control means, the control unit 11 possesses a unit 11A for setting a target power generation amount, a unit 11B for setting a target airflow amount, a unit 11C for feedback-controlling an airflow amount, and a unit 11D for outputting a control signal for controlling the power driving unit. As the block for attaining the function of controlling the air pressure control means, the control unit 11 possesses a unit 11E for setting a target air pressure, a unit 11F for feedback-controlling the air pressure, a unit 11G for instructing the opening of the backpressure control valve, a unit 11J for switching the input, a unit 11K for outputting a control signal for controlling the opening, and a unit 11H for setting the opening the backpressure control valve. The control unit 11 also possesses as the block for attaining the function of the hydrogen pressure control means, a unit 11L for setting the opening of the pressure control valve and a unit 11M for outputting a control signal for controlling the opening of the pressure control valve.

[0026]

Each of the functional blocks possessed by the control unit 11 will now be described. To the unit 11A for setting a target power generation amount receives a signal α of an accelerator angle from an accelerator sensor 10. The accelerator sensor 10 is composed, for example, of a potentiometer, which detects an angle α of the accelerator

pedal (not shown) to be stepped in accordance with the change in the load of the fuel cell carried vehicle. The angle α of the accelerator pedal output from the accelerator sensor 10, which is an analog signal, is then converted into a digital signal, which is input to the unit 11A for setting a target power generation amount. The unit 11A for setting a target power generation amount makes a map research for seeking a target power generation amount corresponding to the signal of the accelerator angle α, and a signal concerning the researched target power generation amount IT is output to the unit 11B for setting the opening of the pressure control valve.

[0027]

Based upon the signal concerning the researched target power generation amount IT received from the unit 11A for setting a target power generation amount, the unit 11B for setting a target airflow amount makes a map research for seeking an airflow amount required for attaining the target power generation amount IT, and outputs the signal concerning the target airflow amount QT to the unit 11C for feedback-controlling an airflow amount and the unit 11E for setting a target air pressure.

[0028]

The unit 11C for feedback-controlling an airflow amount receives the signal concerning a target airflow amount QT from the unit 11B for setting a target airflow amount, and the airflow amount Q outputted from the flow sensor 7D and converted

from the analog data into digital data. The unit 11C for feedback-controlling an airflow amount outputs to the unit 11D for outputting a control signal for controlling the power driving unit, a PID actuation signal QC for rapidly converging the deviation of the airflow amount Q to the target airflow amount QT upon zero by carrying out proportion, integration, or differentiation.

[0029]

The unit 11D for outputting a control signal for controlling the power driving unit produces a pulse width modulation signal (PWM control signal QP) for controlling the current for flowing through the driving motor 7F through pulse modulation based upon the PID actuation signal QC, and outputs it to the power driving unit (PDU) 5.

[0030]

The power driving unit (PDU) 5 is rotates the driving motor 7F at driving current with a prescribed polarity and a prescribed duty ratio by switching operation of a bridging circuit of a power field effect transistor (FET) (not shown) based upon the PWM control signal QP from the unit 11D for outputting a control signal for controlling the power driving unit. Specifically, the driving motor 7E is rotated so that the supercharger (S/C) 7B attains the target airflow amount QT. Although the detail description is omitted, the power driving unit (PDU) 5 is composed so as to rotatably drive the power driving motor (traction motor) (EVM) 2 at current with a

prescribed duty ratio based upon the signal of the accelerator angel α of the accelerator sensor 10.

[0031]

The unit 11E for setting a target air pressure makes a map research for seeking an air pressure required for attaining the target airflow amount QT within the CV value of the backpressure control valve 8A based upon the signal concerning the target airflow amount QT from the unit 11B for setting a target airflow amount, with reference to the map having characteristics as shown in Fig. 3. The target QT searched as described above is then output to the unit 11F for feedback-controlling the air pressure, the unit 11H for setting the opening the backpressure control valve, and the unit 11L for setting the opening of the pressure control valve.

[0032]

The unit 11F for feedback-controlling the air pressure receives the signal concerning a target air pressure PT from the unit 11E for setting a target air pressure, and the air pressure P output from the pressure sensor 7E, converted from the analog data into digital data. The unit 11F for feedback-controlling the air pressure outputs to a unit 11G for indicating the opening of the backpressure control valve a PID actuation signal PC for rapidly converging the deviation between the air pressure P and the target pressure PT upon zero by carrying out proportion (P), integration (I), or differentiation (D).

[0033]

Based upon the PID actuation signal PC, the unit 11G for indicating the opening of the backpressure control valve makes a map research for seeking an opening of the backpressure control valve 8A required for obtaining the target air pressure PT within the CV value of the backpressure control valve 8A, and the signal β for indicating the opening is output to the unit 11J for switching the input.

[0034]

The unit 11H for setting the opening the backpressure control valve receives the signal concerning the target air pressure PT from the unit 11E for setting a target air pressure, as well as the signal of the airflow amount Q from the flow sensor 7D at every 10 ms cycle. Based upon the signal of the target air pressure and based upon the signal of the airglow amount Q, which is gradually changed toward the target airflow amount Qt, the unit 11H for setting the opening the backpressure control valve makes a map research for seeking an opening of the backpressure control valve 8A required for attaining the target air pressure PT one after another at an interval of 10 ms within the CV value of the backpressure control valve 8A, and the resulting signal γ for setting the opening of the valve is output to the unit 11J for switching the input, while altering the signal γ for setting the opening of the valve at an interval of 10 ms.

[0035]

To the unit 11J for switching the input receives the signal β for indicating the opening from the unit 11G for indicating the opening of the backpressure control valve and the signal γ for setting the opening of the valve from the unit 11H for setting the opening the backpressure control valve, and the signal of the airflow amount from the flow sensor Q and the signal of the target airflow amount from the unit 11B for setting a target airflow amount. By comparing the airflow amount Q with the target airflow amount QT, the unit 11J for switching the input outputs the signal γ for setting the opening of the valve from the unit 11H for setting the opening the backpressure control valve to the unit 11K for outputting a control signal for controlling the opening during the course of the transition period until the airflow amount T reaches the target airflow amount QT, while the unit 11J for switching the input outputs the signal β for indicating the opening from the unit 11G for indicating the opening of the backpressure control valve to the unit 11K for outputting a control signal for controlling the opening under the stationary conditions after the airflow amount Q reaches the target airflow amount QT.

[0036]

The unit 11K for outputting a control signal for controlling the opening outputs a driving signal D1 having a given polarity and a given duty ratio in order to PWM-control the opening of the backpressure control valve 8A produced based upon the signal γ for setting the opening of the valve from the

unit 11H for setting the opening the backpressure control valve or the signal β for indicating the opening from the unit 11G for indicating the opening of the backpressure control valve.

[0037]

Based upon the target air pressure PT from the unit 11E for setting a target air pressure, the unit 11L for setting the opening of the pressure control valve makes a map research for seeking a target hydrogen gas pressure slightly greater than the target air pressure, also makes a map research for seeking an opening of the pressure control valve 9B required for attaining the target hydrogen gas pressure, and outputs the signal δ for setting the opening of the valve to the unit 11M for outputting a control signal for controlling the opening of the pressure control valve.

[0038]

The unit 11M for outputting a control signal for controlling the opening of the pressure control valve outputs a driving signal D2 having a given polarity and a given duty ratio in order to PWM-control the opening of the pressure control valve 9B produced based upon the signal δ for setting the opening of the valve to the pressure control valve 9B.

[0039]

In the fuel cell system according to one embodiment configured as described above, when the increase in the power generation amount of the fuel cell (FC) 3 is requested, for example, if the accelerator pedal (not shown) is stepped in,

the accelerator sensor 10 shown in Figs. 1, 2 outputs an accelerator opening signal α in accordance with the amount of the accelerator to be stepped in to the control unit 11. The control unit 11 then controls the flow amount and the pressure of the air compressively transferred to the cathode side according to the change in the target power generation amount of the fuel cell (FC) 3 to be the target airflow amount QT and the target air pressure, respectively, as shown in the functional block diagram of Fig. 2 and the flowchart of Fig. 3, whereby the power generation amount of the fuel cell (FC) 3 is controlled to be the target power generation amount. In this case, during transition period that the airflow amount Q is gradually changed toward the target airflow amount QT, the air pressure P is controlled to be a target air pressure QT one after another corresponding to the gradual change in the airflow amount Q.

[0040]

In the control unit 11, the unit 11A for setting a target power generation amount, which receives the signal α of the accelerator opening from the accelerator sensor 10 makes a map research for seeking a target power generation amount IT in accordance with the signal α of the accelerator opening (S1), and outputs the produced signal to the unit 11B for setting a target airflow amount. Subsequently, the unit 11B for setting a target airflow amount make a map search for seeking the target airflow amount required for attaining the target power

generation amount IT (S2), and outputs the produced signal concerning the target airflow amount QT to the unit 11C for feedback-controlling an airflow amount and the unit 11E for setting a target air pressure, respectively. The flow sensor 7D detects the airflow amount Q at the cathode inlet side of the fuel cell (FC) 3 (S3), and outputs the detected signal to the unit 11C for feedback-controlling an airflow amount, the unit 11H for setting the opening the backpressure control valve, and the unit 11J for switching the input, respectively.

[0041]

Subsequently, in order to converge the detected airflow amount Q to the target airflow amount QT, the unit 11C for feedback-controlling an airflow amount, the unit 11D for outputting a control signal for controlling the power driving unit, and the power driving unit (PDU) 5 execute feedback control of the revolution number of the supercharger (S/C) 7B (S4). Specifically, the unit 11C for feedback-controlling an airflow amount, which has received the signal concerning the target airflow amount QT and the signal concerning the airflow amount Q from the flow sensor 7D, outputs the PIM actuation signal for converging the deviation between the target airflow amount Qt and the detected airflow amount Q upon zero to the unit 11D for outputting a control signal for controlling the power driving unit. The unit 11D for outputting a control signal for controlling the power driving unit, which has received the PID actuation signal QC, produces a PWM control

signal QP based upon the PID actuation signal QC, which is output to the power driving unit (PDU) 5. Subsequently, based upon the PWM control signal QP, the power driving unit (PDU) 5 drives the driving motor 7F in a rotatable manner at driving current with a prescribed polarity and a prescribed duty ratio whereby the revolution number of the supercharger (S/C) is increased one after another. This increases the airflow amount Q flowing into the cathode inlet side of the fuel cell (FC) 3 toward the target airflow amount QT one after another as shown in Fig. 5.

[0042]

On the other hand, the unit 11E for setting a target air pressure, which has received the target airflow amount QT from the unit 11B for setting a target airflow amount, outputs a signal concerning the target air pressure PT required for attaining the target airflow amount QT within the CV value of the backpressure control valve 8A to the unit 11F for feedback-controlling the air pressure, the unit 11H for setting the opening the backpressure control valve, and the unit 11L for setting the opening of the pressure control valve, respectively.

[0043]

The unit 11L for setting the opening of the pressure control valve, which has received the target air pressure PT, sets a target hydrogen gas pressure which is an appropriate pressure slightly greater than the target air pressure PT, and

outputs a signal δ for setting the opening of the valve required for attaining the target hydrogen gas pressure to the unit 11M for outputting a control signal for controlling the opening of the pressure control valve. Then, the unit 11M for outputting a control signal for controlling the opening of the pressure control valve outputs a driving signal D2 having a given polarity and a given duty ratio in order to PWM-control the opening of the pressure control valve 9B produced depending upon the signal δ for setting the opening of the valve to the pressure control valve 9B. As described above, the pressure of the hydrogen to be supplied into the anode inlet of the fuel cell (FC) 3 is adjusted to be an appropriate pressure slightly greater than the target air pressure PT.

[0044]

Here, in the flowchart of Fig. 4, based upon the change $\Delta\alpha$ in the accelerator opening signal α with the time elapse or based upon the change ΔQT in the target airflow amount QT with the time elapse, the target power generation amount IT is judged whether it is changed or not (S5). If the judged result at the step S5 is "YES", the airflow amount Q is subsequently judged whether or not it is converged to the target flow amount QT (S6).

[0045]

In the case, the result of the judgment in Step S6 is "NO", which is assumed to be during the transition period that the airflow amount Q flowing toward the cathode inlet side of the

fuel cell (FC) 3 is gradually changed toward the target airflow amount QT, the unit 11H for setting the opening the backpressure control valve, the unit 11J for switching the input, and the unit 11K for outputting a control signal for controlling the opening controls the air pressure P at the cathode inlet side to be a target air pressure PT one after another corresponding to the airflow amount Q, which is gradually changed. Specifically, the unit 11H for setting the opening the backpressure control valve, which has input the signal of the target air pressure PT and the signal of the airflow amount Q from the flow sensor 7D, makes a map search for seeking the opening of the backpressure control valve 8A required for attaining the target air pressure PT one after another corresponding to the airflow amount Q, which is gradually increased toward the target airflow amount QT (S7), the signal γ for setting the opening of the valve is output to the unit 11J for switching the input, while altering the signal γ for setting the opening of the valve at 10 ms cycle. Subsequently, the unit 11J for switching the input outputs the signal γ for setting the opening of the valve from the unit 11H for setting the opening the backpressure control valve to the unit 11K for outputting a control signal for controlling the opening, and the unit 11K for outputting a control signal for controlling the opening outputs a driving signal D1 having a given polarity and a given duty ratio in order to PWM control the opening of the backpressure control valve 8A corresponding to the signal

γ for setting the opening of the valve to the backpressure control valve 8A, whereby the opening of the backpressure control valve 8A is controlled to be γ (S8). In this case, the value of the signal γ for setting the opening of the valve is set to be such characteristics that it is once decreased at the initial stage of starting the increase in the airflow amount Q as shown in Fig. 5, and, thereafter, it is increased according to the increasing of the airflow amount Q. For this reason, the air pressure P at the cathode inlet side of the fuel cell (FC) 3 is increased one after another without once decreasing the pressure as in the case of the prior art shown as the broken line.

[0046]

On the other hand, in the flowchart of Fig. 4, in the case where the judged result at the step S5 is "No" or where the judgment at the step 6 is "Yes", and the real airflow amount Q detected by the flow sensor 7D has reached the target airflow amount QT, the unit 11F for feedback-controlling the air pressure, the unit 11G for indicating the opening of the backpressure control valve, the unit 11J for switching the input, and the unit 11K for outputting a control signal for controlling the opening execute feedback control of the opening of the backpressure control valve 8A so that the real air pressure P detected from the pressure sensor 7E is converged to the target air pressure QT. Specifically, the unit 11F for feedback-controlling the air pressure outputs to a unit 11G for

indicating the opening of the backpressure control valve a PID actuation signal PC for rapidly converging the deviation between the detected air pressure P and the target pressure PT upon zero. Then, based upon the PID actuation signal PC, the unit 11G for indicating the opening of the backpressure control valve, which has input the PID actuation signal PC, makes a map research for seeking an opening of the backpressure control valve 8A required for obtaining the target air pressure PT within the CV value of the backpressure control valve 8A (S9), and the resulting signal β for indicating the opening is output to the unit 11J for switching the input. Subsequently, the unit 11J for switching input outputs the signal γ for setting the opening of the valve from the unit 11H for setting the opening the backpressure control valve 8A to the unit 11K for outputting a control signal for controlling the opening, and the unit 11K for outputting a control signal for controlling the opening outputs a driving signal D1 having a given polarity and a given duty ratio in order to PWM-control the opening of the backpressure control valve 8A produced based upon the signal γ for setting the opening of the valve, whereby the opening of the opening of the backpressure control valve 8A is controlled to be β (S10).

[0047]

Specifically, according to the fuel cell system and the process for controlling the fuel cell according to one embodiment of the present invention, during the transition

period that the airflow amount Q at the cathode inlet side of the fuel cell (FC) 3 is gradually changed toward the target airflow amount QT, corresponding to the change in the flow amount Q of the air flowing towards the cathode inlet side, which is detected by the sensor 7D one after another, the air pressure control means controls the air pressure P at the cathode inlet side to be the target air pressure PT one after another. Consequently, the increase in the pressure difference between the poles within the fuel cell (FC) 3 can be prevented, ensuring the prevention of the damage of PEM making up MEA of the fuel cell (FC) 3. What is more, the time delay by which the air pressure P at the cathode inlet side reached the target air pressure PT can be solved, improving the response to the increase or decrease in the power generation amount of the fuel cell (FC) 3.

[0048]

As described above, according to the fuel cell system and the process for controlling the fuel cell according to the present invention, during the transition period that the airflow amount at the cathode inlet side of the fuel cell is gradually changed toward the target airflow amount, in response to the change in the target airflow amount, corresponding to the change in the flow amount Q of the air flowing towards the cathode inlet side, which is detected by the sensor one after another, the air pressure control means controls the air pressure at the cathode inlet side to be the target air pressure.

Consequently, the increase in the pressure difference between the poles within the fuel cell can be prevented, ensuring the prevention of the damage of PEM making up MEA of the fuel cell. What is more, the time delay by which the air pressure at the cathode inlet side reached the target air pressure can be solved, improving the response to the increase or decrease in the power generation amount of the fuel cell.

[Brief description of the Drawings]

[Fig. 1]

Fig 1 is a configuration diagram of a vehicle drive system including a fuel cell carried on a vehicle according to one embodiment of the present invention.

[Fig. 2]

Fig. 2 is a functional block diagram of a control system of a fuel cell system according to one embodiment of the present invention.

[Fig. 3]

Fig. 3 is a graph showing the relation between a target airflow amount and a target air pressure in the fuel cell system according to one embodiment of the present invention.

[Fig. 4]

Fig. 4 is a flow chart showing actuating steps of the fuel cell according to one embodiment of the present invention.

[Fig. 5]

Fig. 5 is a graph showing control characteristics during

the course of the transition in the fuel cell system according to one embodiment of the present invention.

[Description of Reference Numerals]

2 power driving motor (EVM) 2

3 fuel cell (FC)

5 power driving unit (PDU)

7 air intake system

7B supercharger (S/C)

7D flow sensor

7E pressure sensor

7F driving motor

8 air exhaust system

8A backpressure control valve

9 hydrogen intake system

9B pressure control valve

10 accelerator sensor

11 control unit

11A unit for setting a target power generation amount

11B unit for setting a target airflow amount

11C unit for feedback-controlling an airflow amount

11D unit 11D for outputting a control signal for controlling a power driving unit

11E

11F unit for feedback-controlling an air pressure

11G unit for instructing an opening of a backpressure control

valve

11H unit 11H for setting an opening a backpressure control valve

11J unit for switching an input

11K unit for outputting a control signal for controlling an opening

11L unit for setting an opening of a pressure control valve

11M unit 11M for outputting a control signal for controlling an opening of a pressure control valve